1. A low pressure or cyclone on the east of a line running north and south and passing through this station.
2. A comparatively steep barometric gradient on the west of the line.
3. Clearing weather and *brisk* winds, but not usually gales, at Augusta, Charlotte, Atlanta, and Chattanooga.

It is thus seen that the conditions that produce northwest gales here are the same as produce northwest winds everywhere; but the difference here is in the fact that a gale occurs at my station when only a fresh or brisk wind is noted elsewhere. The velocity of the winds on the eastern slope of the Blue Ridge is greater than the barometric gradient calls for.

It seems to me that the reason for this may be that the slope of the land *increases the velocity* of the cold, heavy air flowing down an inclined surface, just as the swiftness of a stream is increased in proportion as the bed is steeper. I can not say whether the velocity of winds is commonly increased in this manner, but this is the only reason I can think of to explain the gales. It would seem, therefore, that this is a case resembling the bora wind, the velocity being caused by the descent in that case.

These winds resemble the foehn in their extreme dryness, but I am unable to say whether they are drier than ordinary northwest winds in general. The problem is, therefore, this: Why do severe gales occur on the eastern slope of the Blue Ridge and upper Piedmont region when only *brisk* winds are noted at surrounding stations?

HYDROLOGY OF THE LAKE MINNETONKA WATERSHED.

By GEO. W. COOLEY, C. E., Minneapolis, Minn.

Lake Minnetonka covers an area of 23 square miles and receives its supply from an area of 115 square miles. It is situated in Hennepin County, Minn., at an elevation of 915 feet above sea level and is from 8 to 20 miles west of Minneapolis, the metropolis of the State. Its central point is located in latitude 44° 56′ N. and longitude 93° 36′ W.

The basin is of glacial formation, and its surface is rolling, interspersed with many marshes of irregular outline and varying extent, and was formerly covered with a large body of timber known as the "big woods." The surface soil is from 1 to 2 feet in depth, of rich loam, with a clay subsoil of unknown depth.

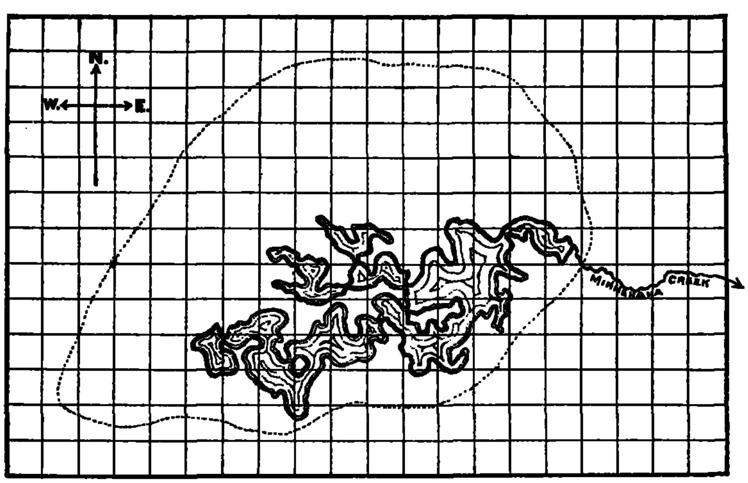

FIG. 1.—Outine of lake and watershed. (Each square represents 1 mile.)

There are occasionally found pockets of sand throughout the basin, but none of great extent, nor any that can be traced as water-carrying strata. In 1864, the year of the writer's first acquaintance with this watershed (which knowledge was considerably enlarged by surveys and explorations during subsequent years), the amount of forest land was approximately 75 per cent of the entire land area. At present it hardly exceeds 20 per cent, the loss occurring entirely through the cultivation of its fertile soil.

By reference to Fig. 1 it will be seen that the outline of the lake is very irregular, with an extreme breadth of 5 miles and a length of 11 miles, the shore line is almost exactly 100 miles in extent, a feature which will be found of considerable importance in determining the proportion of precipitation which enters the lake from the adjacent land.

During the years 1894 and 1895 the writer made a series of soundings covering the entire lake, aggregating many thousands in number, for the purpose not only of determining the depth but also the character of the bottom. The depth in the larger portion of the lake was from 30 to 100 feet, the former being a fair average for the entire lake. The bottom was found invariably covered with vegetable matter and soft mud, which deposit has been produced by the washings from the hillsides and the decay of vegetable matter growing in the lake, and which has resulted in making the bed of the lake literally water-tight. I am so well satisfied from long-continued observations of the imperviousness of this bed that I have not allowed the factor of infiltration to enter into my calculations.

There are no springs of any consequence within several miles of the lake except that known as Purgatory, situated about two miles from its southeastern extremity and about one mile outside the watershed. It was supposed for years by many residents that this spring received its supply through underground sources from the lake, but a careful survey demonstrated the fact that its supply was received from an independent drainage area, mainly covered with tamarack swamp and meadows, which served to produce a fairly regular flow.

With the foregoing description in mind we will proceed to consider the conditions of supply and discharge.

RAINFALL.

The average rainfall at Minneapolis and Lake Minnetonka from 1881 to 1898, inclusive, is 28.14 inches, which latter figure has been used in my calculations, as it was during these years only that the records of rise and fall were kept. The rainfall by years was as follows:

Years.	Yearly.	Summer.	Winter.	Years.	Yearly.	Summer.	Winter.
	Inches.	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*
1881	34.73	27.33	5.58	1890	27.08	22.18	5.49
1882	22.95	16.11	7.28	1891	26.97	17.82	7.63
1883	26.98	21.00	6.41	1892	37.90	33.11	6.71
1884	29.68	22.81	4.32	1893	32.17	23.35	7.42
1885	26.66	23.42	6.97	1894	22.80	17.17	3.54
1886	29.58	20.65	8.16	1895	21.44	18.85	4.36
1887	32.79	23.80	9.53	1896	30.65	22.77	10.11
1888	30.12	24.24	4.53	1897	30.50	23.82	4.24
1889	18.36	12.55	6.34	1898	25.77	21.10	....

Making an average yearly fall, as before stated, of 28.14 inches, which I have divided, as above, into two parts, showing the fall during that part of the year when the lake was open and in that part when it was covered with ice, the latter period generally comprising the months of November, December, January, February, and March.

The average precipitation in this vicinity for fifty-three years ending with 1898 is 27.29 inches. The earlier years of this period were taken from the Fort Snelling records 20 miles east by south. A large majority were from the Minneapolis observations taken 15 miles east, while those for the past eighteen months were from observations taken at the lake.

The averages for these two periods are 21.78 and 6.39, respectively.

PROPORTION OF WATER THAT REACHES THE LAKE.

Great difficulty in determining the coefficient of available rainfall, or the so-called percentage of "run off," has always been experienced and must depend largely upon the judgment of the investigator, except where assisted by actual measurement of the stream carrying the run off and by long-continued and carefully kept records of evaporation.

The first series of measurements of Minnehaha Creek, the only outlet of the lake, were taken during the years 1871 to 1878 and resulted in showing an average discharge of 75 to 90 cubic feet of water per second, the latter of which would give about 0.80 cubic foot per second per square mile of drainage area, an estimate considerable higher than the average of Minnesota watersheds.

After the spring of 1881 the writer established a system of water gauges on the lake, which have been carefully maintained ever since, and from this record has been prepared a profile of the various stages of water, shown on Fig. 4. It will be noticed by this profile that there were three periods during which no water ran out of the lake, the first comprising a period of thirty-two and one-third months, from September 15, 1889, to May 25, 1892; the second from August 15, 1895, to April 15, 1896; and the third from July 15, 1896, to February 15, 1897. The very small amount that flowed out during the early part of the first period has been disregarded as not being sufficient to affect the calculations.

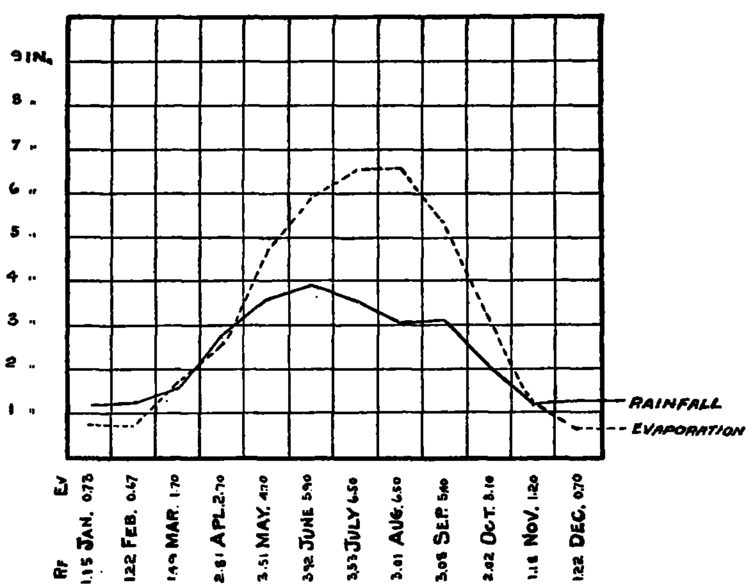

FIG. 2.—Evaporation and rainfall.

There were a number of other periods, of from one to two months, during which the flow of the creek was stopped by a dam a few miles below the outlet, and during such periods of dead water daily observations were taken of the rise and fall of the lake, rainfall, inflow, etc., for the purpose of determining the evaporation, and at one time such records were kept for about five hundred consecutive days.

Frequent measurements were also made of the flow from the lake at every stage of water, and while these observations were not continuous, sufficient were taken to insure a fairly accurate result. From these various measurements, among which the rise and fall have been continuously kept for eighteen years, I have estimated the percentage of rainfall collected by the lake at 42, and while this is seemingly in excess of the amount generally considered as available from a watershed of this nature, it must be noticed, by an examination of Fig. 1, that 35 square miles of the watershed lie within 1 mile of the lake and within the next mile zone there are 20 more square miles of drainage ground.

These conditions are favorable to a very large factor of available rainfall over at least 60 per cent of the gathering ground, and this factor would, in time of heavy showers, when the soil was highly saturated, probably reach as high as 75 per cent. From such conditions I consider the general factor of 42 per cent as close as can be attained.

EVAPORATION.

This factor was not obtained from the use of evaporating pans, but by actual measurement on the entire lake surface during the times when the lake was a closed basin.

During these periods several gauges were established at different points on the lake, from 3 to 5 miles apart, and simultaneous readings taken. From these observations, carefully checked, I append the following table of monthly evaporation from a natural water surface in this vicinity:

	Inches.
November 15 to April 1	4.3
April	2.7
May	4.7
June	5.9
July	6.5
August	6.5
September	5.4
October	3.1
November 1 to November 15	0.7
A total of	39.8

I refer, by permission, to the report of Mr. Tracy Lyon, master mechanic of the Chicago Great Western Railway, who, in a report to the White Bear Lake Improvement Association in 1897, gives the evaporation from the surface of the lake as follows:

	Inches.
January	0.5
February	0.7
March	1.3
April	2.4
May	3.8
June	5.3
July	6.2
August	5.9
September	4.8
October	3.4
November	2.1
December	0.9
Total	37.3

As to the evaporation during the months when the lake was covered with ice, this has been determined in several ways; first, by an actual measurement of the fall of water during the winter, including a period commencing after the freezing of the ground and ending before the spring supply was released from the land; second, by measurement of the loss of snow in places protected from interference by other agencies. For some observations on evaporation from ice and snow surfaces at low temperatures the writer would refer to the following:

Fitzgerald on Evaporation, Transactions of American Society of Civil Engineers, Vol. XV, pages 610 and 614.

Fanning's Water Supply Engineering, page 87.

Loomis's Treatise on Meteorology, page 56.

Greely's Report, Expedition, Lady Franklin Bay, Vol. II, pages 366, 370, 371.

Hayes's Arctic Boat Journey, 1854, page 157.

Richardson's Franklin Search Expedition, page 299.

Hayes's Voyage of Discovery Toward the North Pole, 1861.

Four of which refer to evaporation in high northern latitudes, under temperatures from 50° to 90° below freezing point.

Fig. 3 shows the monthly ratios of outflow from the lake, together with the curve of the same for the St. Croix River.

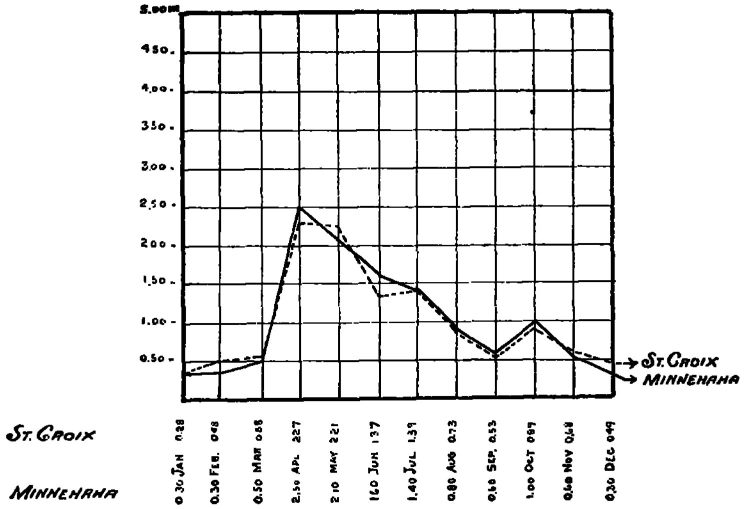

FIG. 3.—Monthly ratio of flow, Minnehaha Creek and St. Croix River.

which enters the Mississippi about 50 miles southeasterly, the watershed of which very closely approximates in its surface conditions that of Lake Minnetonka.

RUN OFF.

The actual run off in any stream may be determined by the following formulæ:

For a watershed without lakes

$$F = 0.884\ L\ R\ C.$$

For a watershed with large lakes as receiving reservoirs

$$F = (R + \frac{LRC}{W} - E) \times 0.884\ W, \text{ in which}$$

F = Flow in cubic feet per second.
R = Precipitation in feet.
L = Land surface of watershed in square miles.
W = Water surface of reservoirs in square miles.
E = Evaporation in feet.
C = Coefficient of available rainfall.

The constant 0.884 is equal to the number of feet in a square mile divided by the seconds in a year.

With a watershed of 115 square miles, of which 90 miles is land surface, the following will be the conditions for the flow of Minnehaha Creek:

$L = 90.$
$R = 2.345.$
$W = 25.$[1]
$E = 3.317.$
$C = 0.42.$

Applying the formula, we have:

F = 56.86 cubic feet per second as the average yearly flow or discharge from Lake Minnetonka. By using the first formula for the flow from the land surface into the lake, F = 78.34 cubic feet per second, leaving 21.48 cubic feet per second, in addition to the rainfall of 2.345 feet on the lake surface as entirely lost by evaporation; a total loss of 39.8 inches, or 3.317 feet. From the foregoing observations and calculations, I offer the following conclusions concerning this watershed:

Total area	115 square miles.
Land area, including small lakes	90 square miles.
Lake Minnetonka	25 square miles.
Annual precipitation	2.345 feet.
Annual evaporation from lake	3.317 feet.
Coefficient of available rainfall	0.42.
Run off per second from land surface to lake	78.34 cubic feet.
Run off per second from lake	56.86 cubic feet.
Precipitation per second per square mile	2.073 cubic feet.
Run off to lake per second per square mile	0.870 cubic feet.
Run off from lake per second per square mile	0.494 cubic feet.
Proportion of run off to precipitation	23.83 per cent.

It will be interesting to note the gradual decrease in the average stage of water in this lake, as shown by the water gauge records. Commencing at 1885 and taking the average of the three preceding years as a starting point, the succeeding averages are as follows:

Year.	Averages.	Year.	Averages.	Year.	Averages.
	Feet.		*Feet.*		*Feet.*
1885	221.29	1890	220.52	1895	220.20
1886	221.08	1891	220.28	1896	220.06
1887	220.93	1892	220.21	1897	220.02
1888	220.97	1893	220.39	1898	220.00
1889	220.78	1894	220.30		

As the years 1882 and 1883 were years of exceedingly high water it will not do to assume that the average stage has lowered 1.29 foot since 1885. I think, however, that during the past thirty years there has been at least one foot of lowering of the average stage which has undoubtedly been caused by the increase of evaporation from the land surface and consequent decrease of the coefficient of available rainfall.[1]

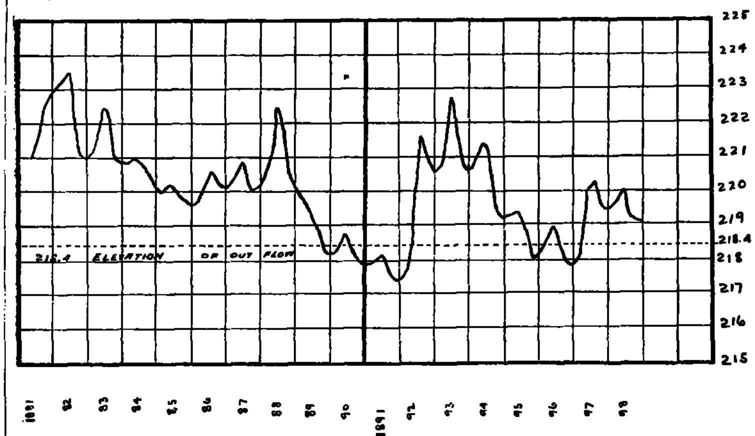

FIG. 4.—Profile of rise and fall.

The run off from land surface to lake during the several months is estimated as follows:

November 15 to April 1 precipitation 5.67 inches, of which 4.3 inches evaporated from the lake surface, leaving a gain on the lake surface of 1.37 inch, to which must be added 5.67 inches precipitation on the land surface, minus 3 inches lost by evaporation equal to 2.67 inches on 90 square miles. Of this land water 75 per cent reaches the lake in the spring flow.

	Inches.
November 15 to April 1 a total of	12.88
April, 75 per cent of land water plus rainfall	11.40
May, 60 " " " " " "	11.09
June, 35 " " " " " "	8.86
July, 25 " " " " " "	6.71
Aug. 25 " " " " " "	5.72
Sept. 30 " " " " " "	6.41
Oct. 50 " " " " " "	5.66
Nov.[2] 60 " " " " " "	1.85
Total received in lake	70.58
Less evaporation	39.83
Net for discharge	30.78

The average flow of 56.86 cubic feet per second will draw

[1] Though the lake proper is but 23 square miles in extent, there are 2 square miles of adjoining marshy shores which for all purposes of storage and evaporation are assumed to be part of the lake.

[1] This assumes that the average rainfall has not changed.—ED.

[2] Fifteen days.

from the lake a depth of 0.00717 feet per day, equal to 30.88 inches per year.

As a rule the entire winter precipitation, generally of snow, is retained on the land and lake surface until about April 1, when all that remains after evaporation is carried very quickly by the spring thaw into the lake.

Further experiments and measurements will be made by means of a weir cut in the dam lately erected by the county at the outlet, and the daily flow determined more accurately, for the purpose of verifying or correcting the estimates of flow herein given. All of which results will be presented to the public in due course of time.

NOTES BY THE EDITOR.

CHARLES S. GORGAS.

Mr. Charles S. Gorgas, observer, Weather Bureau, died at Norfolk, Va., 1:30 a. m. January 21, 1899; age 42 years. His death is announced with regret and his connection with the Bureau will be pleasantly remembered by those with whom he was associated. Mr. Gorgas was born in New York City and was educated in the public schools of that city and in the Spencerian Business College at Washington, D. C. He entered the Government meteorological service November 16, 1882, and performed duty at the following-named stations: Cape Henry, Va., Atlanta, Ga., and Norfolk, Va., as assistant; Fort Robinson, Nebr., Fort Laramie, Wyo., Valentine, Nebr., and Savannah, Ga., as official in charge; and at Washington, D. C., as clerk.—*H. E. Williams.*

METEOROLOGICAL RECORDS IN IOWA.

Mr. J. P. Walton publishes in the Saturday Mail, Muscatine, Iowa, a paper read by him before the Muscatine Academy of Science of February 13, 1899, relative to the early work of Hon. T. S. Parvin. Mr. Parvin settled in Cedar Rapids, Iowa, July 4, 1838, but soon removed to Bloomington, now Muscatine. He apparently began keeping a weather record on December 1, 1838, in diaries and blanks of his own devising; beginning with 1847 he used the Smithsonian blanks. His barometric record began in 1850. In order to get his barometer out to this distant place in 1850, a friend brought it to him from Washington carefully strapped upon his back. When Mr. Parvin moved from Muscatine to Iowa City in October, 1860, he turned over the instruments and records to Rev. John Ufford, and in April, 1863, the latter turned them over to Mr. Josiah P. Walton who now has the complete collection since January 1, 1839.

It is very rare that an observer has the privilege of consulting such a long record at one place, and we hope that Mr. Walton will favor the readers of the MONTHLY WEATHER REVIEW with many studies into the climatic changes that have taken place in Iowa. His paper read before the Muscatine Academy gives us a foretaste of what may be expected. For instance, he finds that in fifty years there have been ten Januaries that have had less than one inch of rainfall. They may be called dry Januaries, and of these ten months he says:

> The Februaries that followed were six wet and four dry; the Marches were three wet and four dry, the other three being average; the Aprils were six wet and two dry; the Mays were eight wet and one dry; the Junes were five wet and one dry; the Julys, six wet and one dry, so that on the whole the ten dry Januaries were followed by an increase of precipitation in every month. Of these ten dry Januaries, three were preceded by dry Decembers and two by wet Decembers, the remaining five being average.

Applying this result to the current year, he says:

> December, 1898, and January, 1899, were dry, but unless the next six months are an exception to former years, we can look for a better season for grass and for oats than for corn. Oats and grass prosper better with April, May, and June wet and July dry for harvesting. Corn requires but little rain until July, but will stand any amount after shooting.

HISTORY OF WEATHER TELEGRAPHY.

Mr. William Foster, jr., of Warwick, R. I., sends to the Editor some interesting notes about the early agitation of the question of a Government weather bureau. He states that—

> In 1837–39 I published the Windham County Gazette, at Brooklyn, Conn., and occasionally had a paragraph on the subject of the weather, advocating a systematic series of observations to develop the law of storms. I removed to Providence in 1856, where I also had something to say on this subject in the press, insisting that the Government should extend its weather work as widely as possible. Subsequently I reported auroras, meteors, etc., to Prof. Joseph Henry. I recollect that in one of my early paragraphs I instanced a severe damaging West Indian storm, which had traveled up the coast, as an example to illustrate the beneficent results that would have been attained if its progress had been noted and transmitted northward.

THE TUGRIN FOG DISPELLER.

This consists of an outlook pipe, 8 feet long and 3 inches inside diameter, with a wide flange at the mouth, placed so as to be convenient to the navigating officer. A tube enters the pipe from below and a blower sends a powerful stream of warm air through the tube and the pipe straight ahead, blowing a hole right through the fog, which is rolled back in every direction; the moisture is said to condense and fall in raindrops, and the navigating officer is enabled to see through the densest fog for several hundred feet.

If this blower operates satisfactorily in a horizontal direction, it ought also to do so in a vertical, and the region around the blower should, therefore, be well wetted by the raindrops that are thus formed out of the fog. It may be an expensive operation, but we commend it to attention on the coast of California, where it is desired to utilize the fog.

THE INTERNATIONAL DATE.

With the increase in rapid transit and ocean cables across the Pacific, it becomes more and more desirable to adopt a system of dates and hours that will be free from the uncertainties and confusions of the present.

The committee on standard time, which made a report to the American Metrological Society in 1875, out of which grew the first step in the reformation of time reckoning, concluded its report by expressing a belief that the only permanent, satisfactory solution of the question would consist in using Greenwich time and Greenwich dates throughout the whole globe. The Greenwich day begins, according to our civil reckoning at Greenwich, midnight, which is simultaneous with local noon on the one hundred and eightieth meridian, near the middle of the Pacific Ocean.

The details of the times at which various events have occurred in Europe, Asia, and America, from day to day, as published in our daily telegraphic columns, keep one continually consulting the degrees of longitude and perpetually figuring out how long it is since they happened.

All this is rectified the moment we begin to use one single